HEATING DRYING TYPE INFRARED RADIATION MOISTURE METER

FIELD OF THE INVENTION

[0001] The present invention relates to a heating drying type infrared radiation moisture meter for performing determination of moisture content of, for example, grain.

BACKGROUND

[0002] A conventional exemplary heating drying type infrared radiation moisture meter will be described with reference to FIG. 7.

[0003] With a conventional exemplary heating drying type infrared radiation moisture meter as shown in FIG. 7, a load meter 35 is disposed inside of a box-like cabinet 38, and at an upper end of a weighing column 35a for this load meter 35, a saucer 34 and a sample plate 31 for placing a sample thereon are mounted.

[0004] Above the cabinet 38, a reflecting plate 36 and a lower windscreen 32b are fixed such that they surround the weighing column 35a, and above the lower windscreen 32b, an opening and closing type upper windscreen 32a is disposed such that it surrounds the sample plate 31.

[0005] Inside of the upper windscreen 32a, an infrared lamp 33 and a temperature sensor 37 using a thermistor are disposed. By virtue of the infrared lamp 33, a sample on the sample plate 31 is irradiated with infrared radiation to heat the sample for evaporating moisture contained in the sample, and a weight of the sample is measured to perform a prescribed calculation for determining the moisture content of the sample.

[0006] The temperature sensor 37 detects a sample temperature for on/off control of the infrared lamp 33.

[0007] With a conventional exemplary heating drying type infrared radiation moisture meter as shown in FIG. 7, it is originally ideal that a surface temperature of the sample is detected by the temperature sensor 37, however, this is actually difficult.

[0008] A temperature detected by the temperature sensor 37 is neither a temperature of the infrared lamp nor the surface temperature of the sample. In detail, the temperature detected by the temperature sensor 37 is a combination of a temperature of so-called radiant heat, which is as a result of the temperature sensor 37 itself absorbing infrared radiation emitted from the infrared lamp 33, and an ambient temperature in the chamber formed by the upper windscreen 32a.

[0009] In this case, if a relationship between the temperature detected by the temperature sensor 37 and the temperature of the sample surface is always constant, there arises no problems. In other words, if the temperature sensor 37 can precisely detect a temperature, the temperature of the sample surface can also be precisely controlled. However, actually, such a relationship is not always constant for the following reasons:

[0010] (1) Relative distances among the infrared lamp 33, the temperature sensor 37, and the sample surface may vary from unit to unit, which results in a multiple error.

[0011] For example, if a distance between the infrared lamp 33 and the temperature sensor 37 is shorter than a specified distance, an energy density of infrared radiation in the vicinity of the temperature sensor 37 is higher than a specified value, and a temperature of the temperature sensor 37 reaches a setting temperature at a higher speed; thus, the infrared lamp itself is controlled at a value lower than a desired value, which causes a surface temperature of a sample to be controlled at a lower value.

[0012] (2) An error due to a difference in ambient temperature in the chamber at a start of measurement may be produced.

[0013] In detail, an ambient temperature in the chamber at a start of measurement for a first time in a particular day is near room temperature; however, an ambient temperature in the chamber at a start of measurement for second and third times is raised under influence of measurement for a previous time. In addition, a value of increase in temperature may vary. Such a difference in temperature between ordinal numbers of measurement may cause an error.

[0014] Specifically, as shown in FIG. 8, assuming that a control temperature is set at 120°C, and a temperature of the temperature sensor at the start of measurement for the first time is 25°C, the temperature of the temperature sensor at the start of measurement for the second time would be 70°C, which would result in a required time period of heating (full-power heating) by the infrared lamp 33 for the first time of measurement being "a", compared to "b" for the second time of measurement, which would create a difference in a dried condition between samples sequentially placed on the sample plate 31.

[0015] (3) A difference in color between samples may produce an error.

[0016] With the conventional exemplary heating drying type infrared radiation moisture meter as shown in FIG. 7, the infrared lamp 33 is controlled such that the temperature of the temperature sensor 37 is constant, and a difference in color between samples has not been considered. However, actually, if the color is different between samples, an absorption factor will also differ from sample to sample, and thus if the temperature of the temperature sensor 37 is kept constant, an error due to a difference in surface temperature between samples may be caused.

[0017] The present invention has been developed in consideration of the above stated conventional situation, and is intended to provide a heating drying type infrared radiation moisture meter which allows a precise measurement of moisture content of a sample to be performed independently of an ambient temperature in the chamber at a start of measurement,

with no errors due to a difference in color between samples being produced.

SUMMARY OF THE INVENTION

[0018] The present invention provides:

[0019] [1] a heating drying type infrared radiation moisture meter which detects a temperature of a heated and dried sample by using a temperature detection device for performing moisture content determination, wherein the temperature detection device is configured with a radiation thermometer which performs infrared radiation detection;

[0020] [2] the heating drying type infrared radiation moisture meter according to [1], wherein the radiation thermometer is disposed just above, aslant above, just under, or aslant under a sample plate, which is a component of the heating drying type infrared radiation moisture meter, with a definite separation from a sample on the sample plate being provided;

[0021] [3] the heating drying type infrared radiation moisture meter according to [1], wherein the radiation thermometer is disposed in a location where it is permitted to receive infrared radiation which is conducted through a light conducting member disposed above a sample plate, which is a component of the heating drying type infrared radiation moisture meter;

[0022] [4] the heating drying type infrared radiation moisture meter according to any one of [1] to [3], wherein the radiation thermometer includes a cover of a heat insulating material;

[0023] [5] the heating drying type infrared radiation moisture meter according to any one of [1] to [4], wherein a light receiving portion of the radiation thermometer is provided with a removable clear protection cover;

[0024] [6] the heating drying type infrared radiation moisture meter according to any one of [1] to [5], wherein a heating reference element for performing temperature calibration of

the radiation thermometer is removably disposed inside of the sample plate;

[0025] According to the invention as defined in the above [1], [2] and [4] to [6], the heating drying type infrared radiation moisture meter is configured by using a radiation thermometer for performing infrared radiation detection as the temperature detection device, which allows for a precise measurement of moisture content of the sample independently of an ambient temperature in a chamber at a start of measurement, with no errors due to a difference in color between samples being produced.

[0026] In other words, infrared radiation emitted from a surface of the sample is detected by the radiation thermometer (an average detection wavelength ranging from 6.4 to 14μm) to be subjected to signal processing for determining a surface temperature of the sample. Thus, an advantage of that, if distances of a heater, the radiation thermometer, and sample surface relative to one another are changed, no errors as mentioned in the description of the conventional exemplary heating drying type infrared radiation moisture meter will be produced, is offered.

[0027] In addition, because the surface temperature of the sample is detected with use of the radiation thermometer, a difference between the ambient temperature in the chamber (in an upper windscreen) at the start of measurement for a first time and that at the start of measurement for a second time can have no effect on results of measurement, thereby producing no errors as mentioned in the description of the conventional exemplary heating drying type infrared radiation moisture meter.

[0028] Further, because the radiation thermometer utilizes infrared radiation having an average wavelength of 6.4 to 14μm, no light having a wavelength in a band of a visible light region will be detected, which results in no measurement errors due to a difference in color between samples being caused.

[0029] Further, the radiation thermometer includes a cover of a heat insulating material,

and thus an effect of ambient temperature is more reliably eliminated and a high degree of freedom in disposition of the radiation thermometer is provided. A clear protection cover is provided, and thus substances evaporated from the sample and the like can be prevented from entering the radiation thermometer, while the clear protection cover can be freely replaced with a new one. And, a heating reference element for performing calibration is provided, and thus temperature calibration can be easily performed.

[0030] According to the invention as defined in [3], functional effects of the inventions as defined in [1] and [4] to [6] are provided, while the radiation thermometer can be disposed in a lower-temperature environment, and thus an effect of ambient temperature can be eliminated still more reliably.

[0031] [7] a heating drying type infrared radiation moisture meter which detects a temperature of a sample heated and dried on a sample plate by using a temperature detection device for performing moisture content determination, wherein the temperature detection device is a radiation thermometer which includes a cover of a heat insulating material, being disposed just above, aslant above, just under, or aslant under the sample plate with a definite separation from the sample on the sample plate being provided, and has light receiving portion provided with a removable clear protection cover, and wherein a heating reference element for performing temperature calibration of the radiation thermometer is removably disposed inside of the sample plate;

[0032] According to the invention as defined in [7], a heating drying type infrared radiation moisture meter which can provide the functional effects of the inventions as defined in [1], [2] and [4] to [6] as a whole can be offered.

[0033] [8] a heating drying type infrared moisture meter which detects temperature of a sample heated and dried on a sample plate by using a temperature detection device for

performing moisture content determination, wherein: the temperature detection device is a radiation thermometer which includes a cover of a heat insulating material; a light receiving portion is provided with a removable clear protection cover; the radiation thermometer is disposed in a location where it is permitted to receive infrared radiation which is conducted through a light conducting member disposed above the sample plate; and a heating reference element for performing temperature calibration of the radiation thermometer is removably disposed inside of the sample plate.

[0034] According to the invention as defined in [8], a heating drying type infrared radiation moisture meter which can provide the same functional effect of the invention as defined in [3] can be offered.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] FIG. 1 is a schematic drawing showing a general configuration of a heating drying type infrared radiation moisture meter according to the present invention;

[0036] FIG. 2 is a schematic plan view of only an upper windscreen of a heating drying type infrared radiation moisture meter according to the present invention;

[0037] FIG. 3 is a plan view of a radiation thermometer according to the present invention;

[0038] FIG. 4 is a sectional view of a radiation thermometer according to the present invention;

[0039] FIG. 5 is an explanatory drawing showing a configuration of a heating reference element according to the present invention;

[0040] FIG. 6 is a schematic sectional view showing a critical portion of a modification of the heating drying type infrared radiation moisture meter according to the present invention;

[0041] FIG. 7 is a schematic configuration drawing showing a conventional exemplary heating drying type infrared radiation moisture meter; and

[0042] FIG. 8 is an explanatory drawing showing time periods required for heating an infrared lamp at a start of measurement for a first time and that for a second time with the conventional exemplary heating drying type infrared radiation moisture meter.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0043] Hereinbelow, an embodiment of the present invention will be described in detail with reference to the drawings.

[0044] FIG. 1 shows a heating drying type infrared radiation moisture meter according to an embodiment of the present invention. Inside of a box-like cabinet 1, a load meter 2 for measuring a weight of a sample is disposed, and at an upper end of a weighing column 2a, a saucer 3, for example, and a sample plate 4 for placing a sample thereon, such as grain, are mounted.

[0045] In an upper portion of the cabinet 1, a lower windscreen 5 is fixed such that it surrounds the saucer 3 at the upper end of the weighing column 2a and the sample plate 4.

[0046] Above the lower windscreen 5, a cylindrical upper windscreen 6, which is opened at its bottom, and can be opened and closed, is disposed. Inside of this windscreen 6, a pair of heaters 7 for heating the sample is mounted in parallel with a top of the sample plate 4.

[0047] At an edge of the upper windscreen 6, a radiation thermometer 10, as a temperature detecting device that is capable of detecting infrared radiation (with an average wavelength of 6.4 to 14μm), which is described later in detail, is disposed aslant above the sample plate 4.

[0048] In FIG. 1, a cover to be disposed above the cabinet 1 is indicated at 8, and a

control panel for performing various operations is indicated at 9.

[0049] The heating drying type infrared radiation moisture meter according to the present embodiment is configured such that the sample is heated by the pair of heaters 7 for evaporating moisture contained therein, a value of change in weight of the sample that is determined through the load meter 2 is fed to a data processing section 13 through an amplifier circuit 11 and an A/D converter 12, and the data processing section 13 performs a prescribed calculation using a value of the weight before heating the sample for determining a value of moisture content, which is displayed by a display section 14, such as a liquid crystal display.

[0050] A temperature detected by the radiation thermometer 10 and a result of the calculation performed by the data processing section 13 are fed to a control section 15, which uses these values for performing heating control of the pair of heaters 7.

[0051] The amplifier circuit 11, A/D converter 12, data processing section 13, display section 14, and control section 15 are actually loaded in the cabinet 1 (the display section 14 being provided in the control panel 9).

[0052] FIG. 2 is a plan view showing only the upper windscreen 6 in a perspective manner, and this upper windscreen 6 is provided with support arms 16 for opening and closing operations that are not shown in FIG. 1.

[0053] On the sample plate 4, a heating reference element 17 for temperature calibration, that is described later, is disposed.

[0054] Next, with reference to FIG. 3 and FIG. 4, the radiation thermometer 10 will be described in detail.

[0055] With this radiation thermometer 10, a body 21 which is in a shape of a rectangular prism, and a loading cylindrical portion 22 which is projected from one end of the body 21 are integrally configured, and by loading the loading cylindrical portion 22 into a loading hole 6a

provided aslant at an edge of the upper windscreen 6, the radiation thermometer 10 is disposed, for example, aslant above the sample plate 4 in the embodiment as shown.

[0056] The radiation thermometer 10 can be disposed not only aslant above the sample plate 4, but also, for example, just above, just under, and aslant under the sample plate 4, with a definite separation from the sample being provided. However, when radiation thermometer 10 is disposed just under or aslant under the sample plate 4, a surface temperature of the sample is detected through the sample plate 4 rather than directly; and thus, it is preferable that a heat capacity of the sample plate 4 itself be reduced for minimizing an effect of the sample plate 4. To reduce the heat capacity of the sample plate 4, the sample plate 4 may be formed by using a material, such as an aluminum foil, which is thin and good in terms of thermal responsiveness.

[0057] At a projection end of the loading cylindrical portion 22, a light receiving opening 23 is provided, and inside thereof, a detector section 24 is disposed. Inside of the body 21, a thermometer circuit board 25, on which an electronic circuit for operating the detector section 24 and compensating for a temperature drift, is fixed.

[0058] The loading cylindrical portion 22 is formed by using a heat insulating material which is excellently adiathermic, and at the end of the loading cylindrical portion 22 outside the light receiving opening 23, a cap 27 and a removable clear protection cover 26 which is intended to prevent substances evaporated from the sample, and the like from entering the radiation thermometer 10 is provided. The clear protection cover 26 can be freely replaced with a new one.

[0059] FIG. 5 is a view showing a configuration of the heating reference element 17, and the heating reference element 17 in the embodiment as shown is made of aluminum, being colored black or white, and configured by embedding a reference thermometer 19 (a thermocouple) in a circular disk 18 which is subjected to a surface treatment of alumite

(anodizing).

[0060] Temperature calibration using the heating reference element 17 is performed by placing the heating reference element 17 on the sample plate 4, for example, and using the control panel 9 for setting a temperature calibration mode at an automatic calibration mode to match a temperature of the heating reference element 17 (a reference temperature) to a detection temperature of the radiation thermometer 10. Temperature calibration is performed at each of temperatures of 80°C, 100°C, 120°C, and 150°C, for example.

[0061] Because operation of the radiation thermometer 10 is such that the detector section 24 of the radiation thermometer 10 detects infrared radiation emitted from a surface of the sample (an average detection wavelength ranging from 6.4 to 14μm) to subject it to signal processing for determining a surface temperature of the sample, the heating drying type infrared radiation moisture meter according to the present embodiment offers an advantage of that, if distances of the heaters, the radiation thermometer, and the sample surface relative to one another are changed, no errors as mentioned in the description of the conventional exemplary heating drying type infrared radiation moisture meter will be produced.

[0062] In addition, because the surface temperature of the sample is detected with use of the radiation thermometer 10, a difference between ambient temperature in the chamber (in the upper windscreen 6) at a start of measurement for a first time and that at a start of measurement for a second time, for example, can have no effect on a result of measurement, thereby producing no errors as mentioned in the description of the conventional exemplary heating drying type infrared radiation moisture meter.

[0063] Another advantage is that, because the radiation thermometer 10 utilizes infrared radiation having an average wavelength of 6.4 to 14μm, no light having a wavelength in a band of a visible light region will be detected, which results in no measurement errors due to a

difference in color between samples being caused.

[0064] Next, with reference to FIG. 6, a critical portion of a modification of the heating drying type infrared radiation moisture meter according to the present embodiment will be described.

[0065] In the modification as shown in FIG. 6, radiation thermometer 10 is disposed in an area outside upper windscreen 6 which provides a lower-temperature environment, instead of being disposed as shown in FIG. 1.

[0066] In detail, the radiation thermometer 10 is fixed in the vicinity of the upper windscreen 6 with a clear glass plate 28 being mounted in a central portion of a top of the windscreen 6, and thereabove, a mirror 29 as a light conducting member is fixed in an inclined position at an angle of 45° for deflecting a path of infrared radiation from a sample at an angle of 45°, and directing the radiation toward light receiving opening 23 of the radiation thermometer 10. Other configurations of this modification are the same as those of the heating drying infrared radiation moisture meter as shown in FIG. 1.

[0067] According to this heating drying type infrared radiation moisture meter as a modification, an effect of ambient temperature in the upper windscreen 6 can be eliminated still more reliably in addition to the above stated functional effects, because the radiation thermometer 10 is disposed in an area which provides a lower-temperature environment. As a light conducting member, an optical fiber may be used in place of the mirror 29.

[0068] According to the present invention, a heating drying type infrared radiation moisture meter can be provided which allows a precise measurement of moisture content of a sample to be performed independently of ambient temperature in a chamber at a start of measurement, with no errors due to a difference in color between samples being produced.

[0069] Further, a heating drying type infrared radiation moisture meter can be provided

which eliminates the effect of ambient temperature more positively, offers a high degree of freedom in disposition of the radiation thermometer, permits a clear protection cover for the radiation thermometer to be freely replaced with a new one, while allowing substances evaporated from a sample and the like to be prevented from entering the radiation thermometer, and makes it easy to perform temperature calibration.